Efficient selection of suppliers over the Internet

Journal of Management Information Systems; Armonk; Spring 1997; Anitesh Barua; Sury Ravindran; Andrew B Whinston;

Source (subtitle): JMIS
Volume: 13
Issue: 4
Start Page: 117-137
ISSN: 07421222
Subject Terms: Internet, Suppliers, Electronic commerce, Value added resellers, Models, Studies
Classification Codes: 9190: *US*
5250: *Telecommunications systems*
7400: *Distribution*
8302: *Software & computer services industry*
9130: *Experimental/theoretical treatment*
Geographic Names: US

Abstract:
The Internet has become increasingly important to organizations for certain aspects of electronic commerce. Many organizations have set up Web pages to capture the attention of potential buyers and to develop new business relationships. Others have set up indexing services to provide easy search capabilities to perspective buyers. While the unit search and communication costs have been lowered dramatically by the Internet, the cost of evaluating potential suppliers may still be prohibitive, especially for certain types of products and services. Thus, although the Internet makes it possible to locate a large number of new suppliers, an organizational buyer needs to deploy appropriate supplier-selection strategies that consider all cost elements involved in choosing a vendor. An analytical model that allows a buyer to maximize payoff (net of supplier search, communication, and evaluation costs) born from the selection process is developed. Ways the nature of the product and the buyer's expectations about supplier characteristics determine whether a sequential evaluation or bidding should be used in the selection process are presented.

Full Text:

[Headnote]
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[Headnote]
KEY WORDS AND PHRASES: bidding, electronic shopping, Internet, search mechanisms, sequential evaluation, supplier selection.

Introduction

Using the Internet for Advertising and Locating Products and Services

STARTING AS A SELF-REGULATING AND NONCOMMERCIAL ENVIRONMENT, the Internet has undergone significant and rapid changes. A year ago, attorneys Canter and Siegel were severely criticized for attempting to advertise legal services on Internet newsgroups. However, such "blasphemous" acts have the potential to generate increased volume of inquiries leading to potential business (in this case, about a hundred thousand dollars) [17]. In its "Technology Forecast 1996," Price Waterhouse predicts that, while 1995 was the year of exploring the Internet, 1996 would see the rise of electronic commerce; more companies would use the Internet and other computer networks to publicize products and services, place or take orders, exchange payments, transfer business-related information, and identify new trading partners.

Significant technological advances involving electronic commerce (e.g., secure means of making payments, sending confidential documents, and authenticating the identity of senders and receivers1) have created an enormous surge of interest among businesses eager to sell their products and services over the "information superhighway" [18]. Commerce on the Internet began with electronic brochures of a seller organization's products and services, including catalogs and price lists. Presently, we have other services (e.g., "smart" agents 2) that search for a required product or service and even compare prices. In the near future, bids for specific products or services will be processed over the network.

A simple demonstration suffices to show that a vast amount of supplier and product/service information is already available over the Internet. Many commercial organizations have set up their "home pages" on the Web, indicating the nature of the products and services they offer. Suppose an organizational buyer (such as a purchasing manager)3 is looking for value-added resellers (VARs) to provide local area network (LAN) connectivity for his or her firm's offices. Using a Web search engine, the buyer can retrieve a large number of choices. Several search engines such as Infoseek, Yahoo, Web Crawler, World Wide Web Worm, and Lycos use key words to search the titles and contents of these home pages; our own search located 352 potential VARs. This kind of search is facilitated by service organizations that compile indices and directories of vendors, products, and services. A search of the telephone Yellow Pages for a large city abounding in high-technology enterprises, however, furnished a list of 14 firms. Using business directories or trade journals is not much better because the available information on addresses or telephone numbers may be dated. Further, much more initial information is available on network databases, which can be used to create a more focused initial set of suppliers. Thus, in the absence of an electronic network like the Internet, a buyer organization is likely to deal with only a handful of suppliers. The time and cost of potential supplier identification are too high to consider a large pool.

Challenges Posed by the Internet

The Internet makes it feasible for a large number of vendors to advertise their products, services, and expertise to the entire user base of the network. A database search on the Internet may identify a large number of potential suppliers for a negligible search cost. Further, electronic mail and browsers such as Netscape greatly enhance the efficiency of communication between buyers and sellers. Using traditional methods of search and communication, after a buyer locates a potential seller, the former may leave a telephone message, and significant delays can occur before an actual contact is initiated. The multimedia capability of the Web, its integration with electronic mail, and interactive applications based on the Web allow for more efficient interactions between prospective buyers and sellers, which is not feasible with trade journals and printed business directories.

A large number of alternatives may be desirable to the extent that it brings in more competition and allows the buyer to obtain better prices and other attributes than with a limited supplier set-but only if the product (or service) being sought is a standard one, where locating and evaluating the different proposals can be handled, at least in principle, by smart agents. If the product is nonstandard, the availability of a large number of suppliers across the network may lead to a significant increase in the total cost of evaluating voluminous bid documents. While it is possible for smart agents to locate and communicate with sellers and obtain their proposals, a large part of their evaluation still has to be done manually. Unless buyers have some effective supplier evaluation strategies, it may not be possible to unlock the full potential of the technology.

While electronic commerce comprises many aspects, we focus on the idea of an organizational buyer using the Internet as a source of information in the process of supplier selection. To what extent do seller organizations perceive Internet presence as an important part of their overall business strategy? To determine if this is indeed a key consideration (which would provide the motivation to pursue this line of research), we conducted a survey of companies providing networking, network security, and management consulting services. We asked the respondents their reason(s) for putting up Web pages and the extent to which their Web presence had led to an increase in customer contacts. The survey was electronically mailed to 250 VARS (randomly selected from an Internet search); 71 responses were received. The mean Web presence period for the sample was seven months (standard deviation five months). The average increase in customer contacts attributable to Web presence was 28.5 percent (standard deviation 32 percent). Some of the comments we received were: "The objectives [of Internet presence] are to make sure that .... [we] aren't out of date and miss people doing product searches on the Web," "the right people find us-our services are not for everyone," "to facilitate communication. All of this dramatically reduces the `getting to know you' communication and saves time," and "inquiries for consulting are up, and the stature of my firm has increased globally. The main benefit for a small consulting firm such as mine has been the exposure to executives at potential clients." In sum, the respondents (all of whom were providers of a differentiated service) felt that customers were using the Web technology as a source of information to locate potential sellers, and that Internet presence was valuable in generating increased customer contacts. Of course, this does not imply that more business will automatically be generated as a result of Internet presence. A buyer's final selection of supplier(s) depends on many factors including the relative fit with the buyer's needs.

Addressing the Supplier Evaluation Problem

A buyer can identify n suppliers through a database search over an electronic network. There are many ways to evaluate these suppliers, including bidding, announcing minimum requirements, and random sequential evaluation. Bidding involves contacting all n sellers4 in parallel and inviting proposals from all, which are then evaluated and the best supplier is selected.5 In the second mechanism, the buyer specifies a set of minimum attribute levels (e.g., price no higher than $x, delivery time no more than y weeks, etc.) and invites suppliers to turn in bids. Random sequential evaluation has a buyer contacting each of n potential suppliers, one at a time, and evaluating each seller's proposal until, based on a stopping rule, a suitable supplier is found. We address three key research questions:

Given the potentially overwhelming amount of product and vendor information on the network, what evaluation strategies should the "smart" buyer adopt to exploit the technology and choose its vendors with a reasonable amount of effort?

2. How many suppliers should a buyer have in the initial feasible pool?

3. Can Internet applications such as intelligent database engines help generate a more "focused" initial pool? Can the buyer thus increase the efficiency of locating suitable vendors/service providers from the choices available over the electronic network?

Our supplier-selection model yields some interesting results:

For a general class of supplier-selection problems, sequential evaluation with a stopping rule never incurs a higher expected total cost (i.e., the cost of search and evaluation, seller price, and buyer's opportunity costs of seller attributes such as delivery time, risk of doing business, and reliability) than a bidding procedure. In the absence of electronic networks, the sequential evaluation stops earlier, ceteris paribus.

As the number of potential sellers (to be evaluated) increases, the buyer's expected total cost using a sequential evaluation mechanism converges to a certain level. This provides an indication of how many potential suppliers to consider in the initial search process (e.g., in a Web search, usually the buyer has a choice of an upper limit on the number of choices to retrieve; alternatively, the buyer may use intelligent search techniques to create a limited but focused supplier pool).

For every sequential evaluation problem, there is a minimum requirements announcement mechanism, whereby the total expected cost to the buyer from a bidding scheme equals that from a sequential evaluation. This result is useful for cases where legal considerations preclude the sequential evaluation of suppliers.

Prior Research and Motivation

There are several important studies dealing with electronic markets; we start with a brief review of this literature. Malone, Yates, and Benjamin [12] propose that more market-based mechanisms will be chosen over hierarchical governance because of better coordination through information technologies (IT). They suggest that coordination cost and the risk associated with interfirm coordination have been reduced through IT, leading to changes in the balance between hierarchies and markets.

Bakos [2] addresses the strategic implications of the electronic marketplace. He points out that electronic marketplaces reduce the costs incurred by buyers to acquire information about seller prices and product offerings. Search costs incurred by buyers (in obtaining information on products and prices of sellers) introduce inefficiencies in the transactions. Bakos characterizes electronic marketplaces by reduced costs of search, positive externality, significant switching costs (because of sizable investments in systems), large capital investments, and uncertainty regarding the benefits of joining the system. He suggests that homogeneous products (as in commodity markets) result in buyers choosing the seller with the lowest total cost, which includes a seller's price, search, transportation, and other costs. In other markets (characterized by differentiated products), buyers consider both price and other characteristics of the product.

In a paper focusing on the optimal number of suppliers, Bakos and Brynjolfsson [3] conclude that firms are finding it more profitable to work with only a small number of partners. The basic premise is that the coordination costs (comprising the cost of setting up a relationship, search cost, and transaction cost) are lowered by the introduction of IT, and that a lower marginal cost of coordination can potentially lead to an increase in the number of suppliers. However, the increasing importance of noncontractible investments by suppliers (such as quality, information sharing, and innovation) forces firms to provide incentives to their suppliers to make these investments. Thus, reducing the number of suppliers will make them act more like "partners" and less like "contractors." A buyer who keeps numerous alternative suppliers may lower the incentive of each supplier to make these investments. Therefore, it may be optimal for a firm (buyer) to deal with fewer suppliers than that suggested by the tradeoff between coordination cost and expected benefit.

The above-cited studies emphasize the importance of selecting trading partners and the critical nature of the supplier selection process. How can Internet technologies be combined with appropriate evaluation strategies to make the selection process more effective? How can a buyer locate a suitable supplier without incurring a high transaction cost? The economics literature provides references on search and evaluation mechanisms derived from the standpoint of auction theory. Auctions and sequential evaluation with decision rules are examples of buying and selling institutions that can reduce the expected cost involved in exhaustive search and evaluation. For electronic network-based transactions, we are interested in finding an approach that imposes no constraints on the buying or selling policies of the parties involved but optimizes a buyer's behavior over a class of mechanisms6 (such as posting a fixed price, selecting among different types of auctions, evaluating sequentially or in parallel). McAfee and McMillan [13] use the approach of optimizing over a class of mechanisms for vendor search. With costly communication, they show that the optimal mechanism is a marriage of sequential evaluation and auction. The choice between sequential evaluation and auction is also addressed by Arnold and Lippman [1] in a special setting with one seller and multiple buyers under conditions of asymmetrical information. While we are interested in the case involving one buyer and multiple sellers, we still face the general problem of selecting an optimal buying institution for the case of electronic markets.

Motivation for the Study

Our main focus is on evaluation strategies that complement Internet technologies for efficient supplier selection. While the MIS literature suggests that the transaction and coordination costs of dealing with suppliers are declining because of IT, we take the view that the total transaction costs of supplier selection may actually increase substantially with the number of alternative suppliers. The selection process must take advantage of the wider choice of suppliers that a network-based search may reveal, while bypassing the problem of increased evaluation costs. In developing our model, we draw upon McAfee and McMillan's [13] general approach of comparing the marginal cost and benefit of one additional search and evaluation in order to derive a stopping rule for a sequential evaluation mechanism.

An important aspect that deserves special attention is the presence of a competitive market on the Internet. The characteristics of the potential suppliers (e.g., manufacturing costs) are not fully known to the buyer. Some of them will be high-cost (i.e., inefficient from the buyer's standpoint, ceteris paribus), while others will be the low-cost types. By their very existence, the high-cost types cause a negative externality [IS]. That is, the low-cost sellers are worse off than they would be in the absence ol the high-cost types; however, the high-cost types are not better off, in an expected sense. In other words, the ex ante chances of any seller winning its bid is reduced by the existence of marginal suppliers. We need a strategy that will induce a separation between the efficient and inefficient suppliers (with respect to the chosen product or service), and motivate only the efficient suppliers to submit bids. Further, can "intelligent" search tools help a buyer eliminate the high-cost types?

Another important element is the possibility that a sequential evaluation strategy may not always be an available option for a buyer. In many instances, legal issues may prohibit a buyer organization from using this strategy. Governmental regulations may dictate that the buyer advertise their requirement, thus providing equal opportunity to all potential sellers to participate in the bidding process. Does the sequential evaluation process have an equivalent bidding process, whereby a strategy that induces self-selection (by eliminating the high-cost types) also enables the buyer to evaluate all suppliers and choose the best?

Supplier Selection Strategies

Electronic Networks and Costs of Search, Communication, and Evaluation

THE COST ELEMENTS CONSIDERED IN OUR MODEL include (1) supplier-search cost, (2) cost of communication between suppliers and the buyer, (3) evaluation cost for the buyer, (4) current supplier price, and (5) the buyer's opportunity cost of attributes such as quality, reliability, and lead time. Search costs are incurred by a buyer in locating the names and other relevant details of potential suppliers, while communication costs are the actual costs of establishing contact with suppliers and communicating details of the product or service desired. They also include the costs of preparing the documentation that conveys these details. Traditional (manual) methods have the inherent characteristic of longer communication times than electronic methods, as explained earlier. Evaluation costs include the cost of resources used to scrutinize possibly voluminous bid documents or proposals from sellers, to assess the capability of each seller, and to compare prices and other aspects of the proposal. These costs vary with the nature of the product or service sought by the buyer-for standard products (e.g., office supplies, stationery, etc.), each cost element is expected to be lower than the corresponding element for nonstandard products (e.g., EDI mappers, and middleware for database servers).7 We note, however, that with manual methods, the cost elements are still high in absolute terms.8

When we turn to electronic networks and markets, the unit costs of search and communication are lowered, regardless of the nature of the product, because of the wider and faster coverage that networks like the Internet offer. As more users join the network and expand the boundaries of the electronic market, the effect is more pronounced. The evaluation cost, however, is still dependent on the standard versus nonstandard nature of the product. Depending on the complexity of the proposals being evaluated, the evaluation costs can be high enough to offset any gains from the reduced cost of search and communication. Figure 1 summarizes how the electronic network and the nature of the product or service affect the various cost elements.

For a traditional approach to supplier selection, we assume that both the search and the evaluation of suppliers are carried out manually. For Internet-based selection of a supplier of a standard product, the evaluation can easily be automated using smart agents.9 Such agents not only scan the Web and gather names of potential suppliers and their prices but also make a price comparison and present the buyer with the best option in terms of price. Thus, the cost of evaluation of standard products can be lowered through the use of appropriate software applications.

Scope of the Theoretical Model

The model developed here would be most useful for medium-sized purchases of differentiated or customized products and services. For example, a buyer searching for a value-added reseller (VAR) to set up local area networks (LANs) with servers and Internet connectivity would typify this class of procurements. For purchases of relatively low value, a detailed supplier evaluation may be less important, while very large purchases will generally be restricted to a handful of highly specialized firms. In other words, we are interested in settings where a buyer wishes to explore alternatives and where vendor evaluation is not as straightforward as simply comparing prices.

Locating and Evaluating Suppliers

In order to locate potential VARs for LANs, a buyer may search Web sites where prospective VARs have created electronic directories of their product (or service) offerings. Having browsed the information, the buyer would have the option to seek detailed information on a specific product or service, for example, technical specifications, prices, and support services. As mentioned before, we restrict our focus to the supplier-selection phase. Our results have no bearing on whether or not actual business transactions are conducted electronically. However, buyers can include the capability of potential vendors to enter into electronic business transactions as one of the attributes on which supplier evaluation is performed.

The desirable qualities a buyer looks for in a VAR will, in all likelihood, be a combination of attributes such as the cost of installation, training and maintenance, delivery time, willingness to upgrade the hardware and network operating systems, reputation and expertise, vendor viability and transaction risk, and EDI capability or the ease with which the supplier can switch to an electronic commerce mode. While there may be several possible ways to evaluate the VARs, our objective is to arrive at a total cost (seller price plus opportunity costs of attributes) that the buyer incurs for each VAR.

From a pragmatic standpoint, we need to deal with two issues: How to obtain opportunity costs for attributes and how to combine the costs appropriately into a single measure. A variety of techniques have been described in the operations management and marketing literature for evaluation of projects, products, or services based on multiple criteria [6, 16]. Fishbein and Ajzen's [6] model is an expectancy value model that views consumer attitudes to a product as a weighted average of the beliefs a consumer has about the presence of certain attributes, where the weights are the importance the consumer places on these beliefs. Shtub et al. [16] present two methods that operationalize the Keeney and Raiffa [8] "pricing out" approach to multiattribute product or service evaluation.

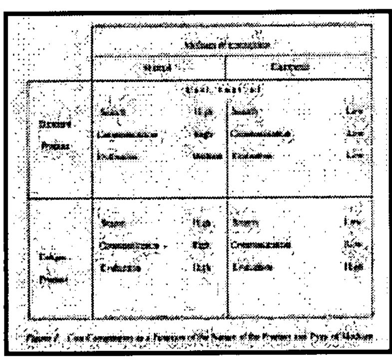

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Figure 1. Cost Components as a Function of the Nature of the Product and Type of Medium

The economics literature suggests a "willingness-to-pay" (wtp) approach to assess the benefit or cost associated with factors such as safety or quality. Theoretically, it is an individual's marginal rate of substitution of money for change in the level of an attribute (e.g., increase in road safety). While any approach to assessing the cost or benefit of relatively intangible factors has limitations, Jones-Lee, Hammerton, and Philips [7] state: "The case in favor of the `willingness-to-pay' approach to the definition of such costs and values has been extensively developed in the literature. . . and is also based upon the ex ante as opposed to ex post assessment of uncertain consequences." For the supplier-selection problem, we need to summarize a buyer's preferences in terms of how much he or she is willing to pay for different levels of attributes of interest. This can be done in two theoretically equivalent ways.

We can measure the cost associated with level xi of attribute i (other than price) as the difference between the wtp at xj* and the price quoted by a supplier with attribute level xi, where xi* is the best possible level for attribute i. Suppose a supplier quotes a price of $5,000, a lead time of one month, and a warranty of six months. Let the best possible states of the above attributes be two weeks and twelve months, respectively. For the cost of lead time,

the buyer has to answer the question: How much more over $5,000 (the current quote) would he or she pay to change the currently quoted lead time of one month to the best possible lead time of two weeks, ceteris paribus?

This approach assumes "preferential independence," which in this example implies that if the buyer is willing to pay $5,500 for a lead time of two weeks, he or she would do so regardless of the quoted warranty period. If this preferential independence does not hold true (i.e., if the wtp for lead time depends on some other attributes say, reliability), then the buyer should consider lead time and reliability together, and answer the following question: How much more over $5,000 would he or she pay for improving the lead time and reliability to their best possible levels? In general, if the attribute set (excluding the price attribute) is not preferentially separable, we partition the attribute set into subgroups of preferentially independent sets, and use the willingness-to-pay approach separately for each subgroup [8]. This procedure is based on one further assumption: The marginal rate of substitution between price and any other attribute or attribute set does not functionally depend on the price level itself. This assumption is very reasonable since the buyer's wtp for improvements in attribute levels should be based on potential gains in profitability or cost savings resulting from such improvements.

How will the buyer know how much he or she is willing to pay? For delivery or lead time, the buyer may consider how much business may be lost or interrupted due to longer lead times. For warranty, what if there is a system failure? What would be the additional cost of getting into a one-time contract for system maintenance? What would be the cost in terms of lost business volume due to customer dissatisfaction, if the system were to go down?

The second approach is based on **multiattribute utility theory** (MAUT) [8, 16]. For each preferentially independent attribute or attribute subgroup, the buyer is asked to rate his or her preference for an attribute level on a scale of 0 to 1, with 0 and 1 being the preference levels for the worst and best attribute levels, respectively. Then the buyer identifies the wtp for the best possible state of the attribute. Finally, the cost of the quoted attribute level is the wtp at the best level multiplied by the preference rating for the quoted attribute level.

The total cost of each supplier is the sum of the base price quoted and the cost associated with each preferentially independent attribute (or subgroup) being evaluated. The formal proof of the additive nature of costs of preferentially independent attributes (or subgroups) is attributed to Debreu [5]; this result is used by Keeney and Raiffa [8] to argue that their "pricing-out" or willingness-to-pay approach to attribute comparison is also additive.

We assume that, based on prior experience or research, the buyer can estimate the parameters of the probability distribution of this total cost. In the theoretical model, we do not assume any functional form for the distribution,lo and hence our results hold true for any underlying distribution. This total cost is one of the factors that helps decide which supplier to choose, or alternatively to reject all potential suppliers and stay with the existing supplier (where appropriate). The buyer selects a lower and an upper bound for the distribution denoted by s and s, respectively.ll An electronic network like the Internet increases the range [s and s] by making available (at a low search and communication cost) a large number of potential suppliers. The other factors that a buyer should use in decision making include (l) the total cost associated with a current supplier (if applicable), c, and (2) the search, communication and evaluation cost, c. The second cost element is that of contacting a supplier, obtaining a comprehensive proposal, and evaluating the overall capability. The cost with the current supplier provides a cutoff level; that is, no supplier with a total cost higher than c will be selected.l2 Similarly, c determines an indifference level c, which is the point where c equals the expected benefit realized by the buyer from one additional search. In other words, if a supplier with a total cost level c is located, then the buyer is indifferent between selecting this supplier and conducting one more search with the expectation of finding a better supplier. A sequential evaluation strategy involves contacting potential suppliers one at a time and evaluating them to determine if the composite cost of the supplier is below c, which constitutes the stopping rule. _c is derived in the appendix. We note that by reducing the unit transaction cost c, the Internet has the effect of reducing the indifference level c. This implies that (1) more suppliers will be evaluated on an average, ceteris paribus, and (2) the expected total cost associated with the selected supplier will be reduced.

Optimal Search Strategy

The supplier-selection strategy adopted by the buyer is dictated by the range [s and s], the cutoff level c, and the indifference level c. Since the buyer is looking for a new supplier, s (the total cost corresponding to the best supplier in the distribution) will be generally lower than c. Otherwise, the optimal strategy for the buyer is to continue with the existing supplier, regardless of the distribution of suppliers. Similarly, if c is smaller than c, the buyer's best strategy is to continue with the existing supplier, because even a single supplier evaluation will make the total cost (search/evaluation cost plus price plus opportunity cost) incurred by the buyer higher than that of the former. Next we consider cases where c is higher than both c and s.

Say the buyer organization has identified a pool of n potential suppliers after a Web search. It has the option of (a) inviting bids from all of them and evaluating every bid, incurring a cost c for each evaluation, but having the benefit of identifying the lowest cost seller, or (b) choosing sellers in a random sequence, evaluating each in turn, and making a decision based on the indifference level identified above. Since (i) c takes into account the expected benefit of additional searches to find a lower-cost supplier, and (ii) c dictates that no supplier above this cost be chosen, the optimal mechanism can be summarized as follows: The buyer sequentially evaluates the suppliers in the pool. If a supplier is found to have a total cost below c, the job is entrusted to that firm, and no further evaluation is carried out. If the supplier has a cost above c, it is rejected. After all n sellers have been contacted, if no one is seen to have a cost below c, the buyer chooses the lowest total cost from this set, provided there is at least one supplier below c. If none has a cost below c, the buyer stays with the existing supplier. Even in the event that there is no existing supplier, the same search mechanism holds true. In that case, c is arbitrarily high, so no supplier is ever immediately rejected.

The expected total cost incurred by a buyer comprises the expected search, communication, and evaluation cost, the expected seller price, and the opportunity costs of other attributes. How does the expected total cost of sequential evaluation vary with n? Because the increased supplier set may include more inefficient sellers, the buyer may have to search more before locating one below c. If it includes more efficient sellers, the buyer may find one below c with the same or fewer number of searches, and the expected price paid may be lower. Two relevant questions for the buyer are: For a given number of sellers, is sequential evaluation at least as good as bidding, always better than bidding, or vice versa?

With sequential evaluation, does the total expected cost incurred increase or decrease with the number of suppliers, n?

Propositions I and 2 and the discussion following each provide answers to these questions as well as some implications for buyer organizations. The proofs of both propositions are provided in the appendix.

Proposition 1: The expected total cost (search/evaluation cost, seller price, and opportunity costs of supplier attributes) incurred by a buyer following a sequential evaluation strategy with a stopping point c is never higher than that incurred with a bidding mechanism.

While there are several possible cases involving the range of total supplier costs and the two bounds, all potential scenarios are covered by proposition I and the discussion immediately preceding this proposition. As illustrated above, our results indicate the importance of adopting the appropriate mechanism for supplier selection depending on the ranges of the composite cost, the cutoff, and the indifference levels. The impact of product type on the optimal strategy occurs through the evaluation cost component, whereby nonstandard products increase the indifference level, leading to the possibility of selecting less efficient suppliers. The composite supplier cost range [s and s] is determined on the basis of prior experience or available information and must necessarily be updated regularly, as new suppliers get added to the list of potential sellers and as current suppliers get deleted from the set. Note that c and c are independent of the number of potential sellers in the buyer's list.

There is a possibility that s will increase owing to the network (especially in the absence of intelligent database search capabilities), and that the buyer may need to evaluate more suppliers before making a selection. This additional evaluation due to the presence of inefficient suppliers is one of the problems encountered while using electronic networks. Later, we outline a minimum requirements announcement mechanism that will discourage inefficient suppliers from entering bids.

For a sequential evaluation process, is there any relation between the number of potential sellers that the buyer has identified and the total expected cost? Is it beneficial to increase the number of potential suppliers, with the expectation of finding a better seller? If so, is there an optimal number that the buyer should opt for in the initial search?

Proposition 2: As the number of suppliers, n, in the initial pool increases, the expected total cost to the buyer using a sequential evaluation mechanism converges to the indifference level c.

As the numerical example in the appendix indicates, ceteris paribus, for successive values of n = 30, 40, 50, 100, and so on, the expected cost converges to the indifference level, $8,750. The marginal reduction in expected total cost decreases; for example, from thirty to forty suppliers, expected total cost falls by about 0.4 percent, from forty to fifty suppliers, by about 0.2 percent, and stabilizes thereafter. The implication for the buyer is that gathering more than thirty suppliers in the initial pool has almost no impact on the efficiency of the supplier selection process in this example. Of course, how quickly the convergence takes place depends on the variability of the supplier distribution. This result has an important bearing on the buyer's strategy, because it suggests a cutoff number of

suppliers in the initial pool based on how close the total expected cost (for a given number of suppliers) gets to the indifference level.

Excluding Inefficient Suppliers from the Selection Process

THE POTENTIALLY OVERWHELMING NUMBER OF SUPPLIERS in the electronic marketplace poses a problem since the additional suppliers discovered on the network may or may not be efficient for the product or service sought by the buyer. The search and evaluation mechanism outlined in the previous section is sensitive to the presence of inefficient suppliers. In fact, the presence of"marginal" or inefficient suppliers affects both the buyer and the efficient sellers. The buyer might (during the course of the sequential evaluation) end up choosing one of the "marginals" because that seller just meets the acceptable attribute levels. For the same reason, the efficient sellers are unfavorably affected.

Also, the expected total cost of the buyer increases with the number of inefficient sellers (whose total costs are higher than the indifference level c). These negative impacts of inefficient suppliers are more pronounced for nonstandard products with high unit evaluation cost. What can a buyer organization do to eliminate the undesirable suppliers from the supplier pool? We suggest that an announcement mechanism, where the buyer sets a minimum acceptable level of attributes such as delivery time, service backup, and maintenance requirements, coupled with a maximum acceptable price, can induce a separation between the "efficient" and "inefficient" suppliers. In other words, by making these announcements, the buyer discourages any supplier who cannot satisfy these criteria from submitting a bid. For a given set of parameters, the buyer can convert the minimum requirements into a total cost level, b, which can be set at an appropriate level (say b*), so as to transform the sequential evaluation process of selecting from n suppliers, into an equivalent bidding process,13 where all the remaining sellers are evaluated and the best awarded the contract.

This result has important implications for a buyer where legal issues preclude a sequential evaluation strategy from being used. Such an equivalent scheme can be implemented to ensure that the buyer still incurs the same total expected cost as with the sequential evaluation. Setting a b higher than b* is not payoff-effective for the buyer, since the total expected cost incurred by the buyer (including evaluation) will exceed that of sequential evaluation. But can the buyer set b equal to or less than the indifference level c? This would imply that all bidders would be better than the indifference level, and the buyer would have to evaluate a very limited number of sellers. The problem here is that there may not be any bids at all, depending on the unit cost of search/evaluation and the distribution of supplier total costs, which may translate to very low probabilities of sellers below c. This is a very likely occurrence given that c is a benchmark cost level. In fact, if the area of the distribution to the left of c is relatively small, the buyer is better off (in terms of a higher likelihood of receiving bids) by setting a higher value of b.

Note that if the buyer implements the announcement mechanism, the efficient suppliers who remain in the fray increase their chances of getting the buyer's business. The announcement mechanism induces a "self-selection" rule where the efficient suppliers will submit their bids. It should be pointed out that each supplier is efficient or inefficient only in the context of the product or service being sought by the buyer, and not in an absolute sense.

Value-Added Services: Intelligent Searching and Evaluation

IN OUR VIEW, ELECTRONIC NETWORKING TECHNOLOGIES AND RELATED applications can complement the evaluation strategies we have proposed. Internet service providers can add value in this supplier-selection process in three related but distinct ways: compiling information on supplier attributes, using intelligent searching to select a focused initial pool, and developing applications to support the proposed evaluation strategies.

To implement the mechanisms discussed in this paper, a buyer organization needs to know the distribution of total supplier costs. Value-added providers can collect details about potential suppliers and their product (or service offerings) and ratings for various attributes. Maintaining a database of such information would benefit both potential buyers and sellers. It would help set up benchmarks that induce sellers to improve their capabilities. It would let buyers assess the expertise available in the electronic market and decide whether to continue with an existing supplier or service provider or look for alternative vendors, and which of the available sellers to select.

Advanced database technologies can help in filtering potentially large amounts of supplier information. When setting up indices to categories and classes of products or services (along with pointers to Web pages of companies offering them), network service providers can add value by compiling key information contained in these home pages in the form of a database, for example, number of years a firm has been in operation, number of qualified personnel in different areas of expertise, average business volume over the last three years, and profiles of major customers. This sets the stage for the use of intelligent search methods to narrow the initial

supplier pool. For instance, a potential buyer may decide to eliminate all vendors who have been in operation for less than five years, or who have a business volume less than a specified level, or who have less than a specified number of employees with expertise in a key area. Once the initial set has been restricted to include only those with a minimum level of expertise, the buyer may then use sequential evaluation or bidding mechanisms with the smaller supplier set. This will lead to a lower transaction cost for the buyer and will also speed up the selection process.

Finally, service providers can help in the selection process by implementing workflow applications that support both sequential evaluation and bidding mechanisms. Such applications will automate some aspects of the information acquisition and evaluation functions underlying each mechanism. While it may take some time for all these capabilities to become available, some promising features are beginning to appear in the form of smart tools on the Internet. For example, Smart Technologies Inc. (URL: http://smart1.imtdirect.com) has implemented software applications that allow potential buyers to specify critical attributes of a product or service in the electronics market (comprising seven categories that include electronic publishing, computers and peripherals, software and information systems, and telecommunications). A buyer can submit an evaluation request form for specific products and have the application generate a list of vendors from which the buyer can elicit further information to make a final choice. Such tools help maximize the potential of the technology by improving the quality and efficiency of communication between buyer and sellers. Note that these tools are not intended to eliminate the actual evaluation of suppliers by the buyer. Rather, they aim to narrow down the choices, such that the buyer starts with a more relevant initial set and quickly converges to a selection. Such tools complement the selection mechanisms we have discussed, since they help to reduce s, and thus lower the total expected cost to the buyer.

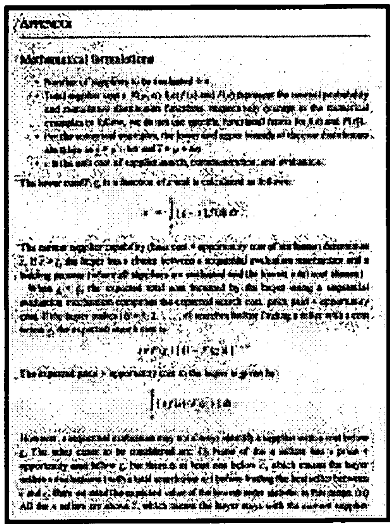
Conclusion

ELECTRONIC NETWORKS SUCH AS THE INTERNET HAVE BROUGHT new opportunities and challenges to business operations. By reducing the costs of search and communication, the Internet makes available a large number of potential suppliers for a buyer organization. However, since the larger pool is likely to contain both efficient and inefficient suppliers, the task of evaluating suppliers assumes greater importance in the presence ofthe Internet. Since IT can help reduce evaluation costs only for standard products or services, buyer organizations need to deploy appropriate strategies for selecting suppliers. In the absence of such strategies, the buyer may have to evaluate a large number of suppliers, which will increase the transaction cost to the buyer.

This paper provides some insights for maximizing the net value of using the Internet for locating suppliers through the deployment of complementary evaluation strategies. In particular, we considered sequential evaluation and bidding systems and assessed their suitability for selecting suppliers based on various factors such as current supplier capability and transaction cost elements. We outlined an announcement mechanism to increase the efficiency of the search process. Finally, we discussed how network service providers can help reduce the buyers' cost through intelligent search engines and workflow applications.

Our future research in this domain will address the following issues: The sequential evaluation process will identify suppliers who are not necessarily the "best." It allows a selection based on expectations. Once a selection has been made and implemented, the buyer has the means to verify the capability of the chosen seller, based on experience (as distinct from the ex ante assessment made earlier). If the revised assessment is unfavorable, the buyer has the option to start the search process all over again, but with a reduced supplier set. This leads to the topic of networked organizations where the continuation of a trading relationship may be contingent on past performance. Clearly, the emergence of global electronic networks will have a profound impact on the nature of interfirm relationships and will open up a gamut of issues for IS researchers.

Acknowledgments: This research was supported in part by the National Science Foundation through grant no. IRI 9210398. We thank Professors James S. Dyer and R. Preston McAfee for many valuable insights. We are grateful to three anonymous reviewers for detailed and helpful comments and suggestions.



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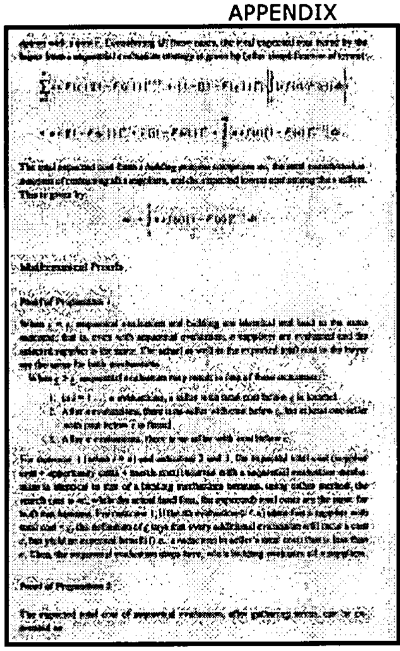

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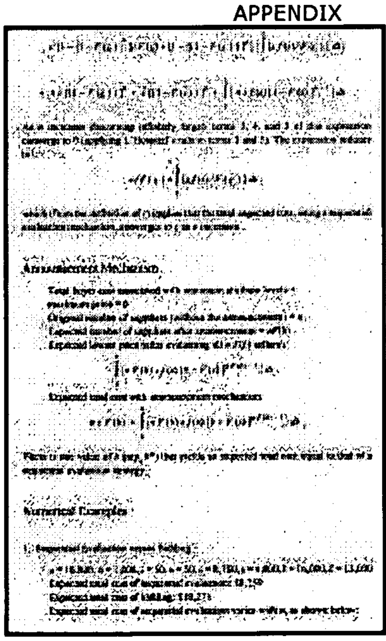

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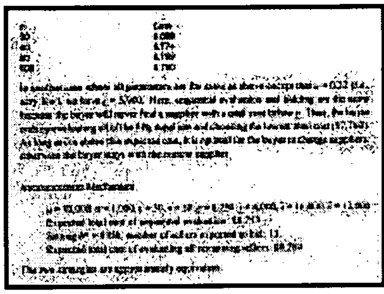

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APPENDIX

[Footnote]
NOTES

[Footnote]
1. Complete security of transactions over public networks such as the Internet has not been attained as yet, but improvements continue to be made daily.
2. A smart agent is a software system that combines communications functions with built-in intelligence. It allows a user to bundle messages, requests, and preferences into a program that communicates with distributed computing systems, obtains answers to queries, and makes decisions based on preferences [19].
3. We do not consider individual (noncommercial) buyers shopping for personal items, because they may not have the power to invite bids from potential sellers. 4. In proposition 2, we discuss what constitutes a reasonable value of n. 5. Note that inviting quotations from all suppliers in the initial set is appropriate only when using the bidding mechanism because once a quotation is obtained it must be evaluated. It is not feasible with sequential evaluation, where a supplier may be selected before all n suppliers have been evaluated.
6. See McAfee and McMillan [13] for a discussion of desirable properties of mechanisms. 7. Most products or services would lie somewhere these two extremes.

[Footnote]
8. For standard products or services, even while using manual methods of search and communication, it may be possible to reduce evaluation costs by automating the evaluation procedure.
9. Shopper's Advantage (URL: http://www.cuc.com) is an example of a search engine that not only gathers information on prices through a Web search, but also compares prices and presents a buyer with the lowest-priced seller. 10. We use a normal distribution only for numerical examples in the appendix. 11. In a pragmatic view, the upper and lower bound are chosen so that almost the entire distribution is contained within the range. For example, in the numerical illustrations involving a normal distribution, we select six standard deviations around the mean).
12. While mathematically it would make no difference to consider this cost as that of an in-house option, our intent is not to analyze a make/buy situation. There is a rich body of IS literature dealing with this topic. For example, Loh and Venkatraman [10,11] address the issue of IT outsourcing based on relative cost advantages and economies of scale and scope. Lacity and Hirschheim [9] compare Williamson's [20] transaction cost model and Pfeffer's [14] political model to understand how IT outsourcing decisions are made. The transaction cost view suggests that economic considerations provide the impetus for outsourcing, while the political model predicts that power and political maneuvering play a definitive role in outsourcing decisions.
13. Equivalence implies that the buyer's expected total costs with the two schemes are identical.

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